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Diet of wolves *Canis lupus* recolonizing Switzerland: a preliminary approach

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Diet of wolves *Canis lupus* recolonizing Switzerland: a preliminary approach. - Dietary analyses were conducted using scat analysis and incidental carcass observations to investigate the diet of wolves returning to Switzerland. Red deer was the most frequent item eaten by wolves with 32.1% and 57.1% of frequency of occurrence in the scats and kills, respectively. Domestic ungulates accounted for 27.1% of the remains found in the scats. Kills were more frequent at lower altitude and at flatter locations than in randomly selected sites. Moreover, the slope of the latter was steeper than that of locations with kills. Wolf predation also occurred at closer distance to the nearest house and to the nearest roads than expected. Finally, gullies and ravines seemed to be a recurrent habitat feature for wolf kills.

Keywords: *Canis lupus* - Swiss Alps - feeding habits.

INTRODUCTION

At the end of the 19th century, the grey wolf, *Canis lupus*, was eradicated from most European countries, including Switzerland (Breitenmoser, 1998). However, a few small populations survived in eastern and southern Europe (e.g. Boitani, 1992). Nowadays, thanks to the extended protection given to this species by the Bern Convention, the improvement of habitats and the increase of wild ungulate numbers, wolves thrive and have expanded their range. The French Alps were colonized since 1992 by wolves from Italy (Houard & Lequette, 1993), with the first records in the Swiss Alps in 1995 (Landry, 1997). Since then, around 25 wolves – all originating from the French-Italian alpine population – have been identified in the latter area (Zimmermann *et al.*, 2009).

Wolf presence is often noticed because of the depredations on livestock (Poulle & Longchampt, 1997, Vignon, 1997). However, with effective livestock protection measures, it is possible to redirect wolves into hunting wild ungulates (Meriggi *et al.*, 1991; Okarma, 1995). In Europe, red deer (*Cervus elaphus*) are often reported as the main prey of wolves (Smietana & Klimek, 1993; Jedrzejewski *et al.*, 2000; Capitani *et al.*, 2004; Nowak *et al.*, 2005), but where cervids are scarce or absent, wolves will hunt wild boars (Pezzo *et al.*, 2003), beavers (Andersone & Ozolins, 2004), domestic animals (Papageorgiou *et al.*, 1994) or will rely increasingly on scavenging (Meriggi *et al.*, 1996).

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No less than six wild ungulate species occur in the Swiss Alps (Table 1). In these circumstances, one could expect a wolf diet mostly constituted at least by one or two of these potential preys. However, the high numbers of unprotected sheep herds found in this region also give the wolf the opportunity to feed on domestic prey. The aim of our study was to describe for the first time the diet of wolves returning to Switzerland. We used two methods to determine diet, as scat analysis alone is thought to be biased by small prey items and incidental carcass identification is biased by large prey items (Hayward *et al.*, 2006). In addition, we examined the possible influence of some habitat parameters on the predation on wild ungulates as observed in other countries (Gula, 2004; Apollonio *et al.*, 2004; Novak *et al.*, 2005 amongst others).

TABLE 1. Overall diet of wolves in the Swiss Alps (i.e. Graubünden, Tessin and Valais) expressed in relative frequency of occurrence (RFO; N = 81 scats).

Species	Nb of items	RFO (%)
Red deer (*Cervus elaphus*)	26	32.1
Roe deer (*Capreolus capreolus*)	17	21
Chamois (*Rupicapra rupicapra*)	4	4.9
Ibex (*Capra ibex*)	3	3.7
Wild boar (*Sus scrofa*)	2	2.5
Mouflon (*Ovis gmelini*)	1	1.2
Wild ungulates	**53**	**65.4**
Goat (*Capra hircus*)	10	12.3
Sheep (*Ovis aries*)	10	12.3
Cattle (*Bos taurus*)	2	2.5
Domestic ungulates	**22**	**27.1**
Vole (*Microtus* sp.)	2	2.5
Marmot (*Marmota marmota*)	2	2.5
Brown hare (*Lepus europaeus*)	1	1.2
Red fox (*Vulpes vulpes*)	1	1.2
Others	**6**	**7.4**

STUDY AREA

Switzerland is a central European country divided into three main geographic regions: the Jura Mountains, the Plateau and the Alps. The Swiss Alps cover around two thirds of the country, but are only inhabited by approximately 11 % of the total human population of nearly 7,500,000 inhabitants. The mean altitude of the Alps region is 1700 m asl. However, about 100 peaks reach or are higher than 4000 m asl. The climate is continental - but may show important local variations - meaning that winters are generally cold and harsh. Tourism and livestock pastoralism are the main human activities in the area.

Most samples used in our analyses come from the Surselva, a 416 km^2 region located in western Graubünden (eastern Switzerland). From the valley bottom where the Rhine river flows (ca. 700 m asl.) to the highest peak (3158 m asl.), different types

of vegetation occur of which spruce, *Picea abies*, - dominated forests are the main feature. Mean annual temperature is 5.9 C° at the altitude of 1190 m asl., and mean annual precipitations reach 1036 mm. Snow cover could be as high as 454 cm per year at 1280 m asl.

MATERIAL AND METHODS

Between June 1999 and May 2006, a total of 81 wolf scats were collected mainly by local game keepers after some depredations on livestock occurred. All samples were submitted to a genetic analysis in order to confirm wolf identification (Fumagalli, 2003). Dietary analyses were performed and vertebrate remains identified following Brunner & Coman (1974), Debrot *et al.* (1982) and Teering (1991) and using a mammalian hair reference collection. Three food categories were considered: wild ungulates, domestic ungulates and other mammals. Results were expressed in relative frequency of occurrence (RFO). During the same period, 63 genetically confirmed wolf kills were recorded throughout the Swiss Alps. Species and age class, i.e. juvenile or adult, were determined. Ivlev's selectivity index (Jacobs, 1974) was used to calculate prey selection by wolves: $D = r\text{-}p/r + p - 2rp$, where r is the fraction of an ungulate species among wolf kills and p the fraction of a species in ungulate community. The calculation was made for Surselva only, since most kills came from there and the results of the yearly ungulate censuses carried out each spring by game keepers were available for this area only.

After excluding 13 locations for which the coordinates were not precise enough for further analyses, 50 kill locations were characterized using various habitat parameters: i) altitude (m asl.); ii) aspect (°); iii) distance (m) to the nearest wood edge; iv) distance (m) to the nearest road; vi) distance (m) to the nearest water way; and vii) distance (m) to the nearest house.

Besides kill locations, 170 locations were chosen randomly in the different areas using S-Plus software (TIBCO Software Inc.) and characterized according to the above-mentioned habitat parameters.

Wilcoxon signed rank test was used to compare occurrence of wild ungulates in scats and among the kills, and habitat parameters between kill- and randomly-chosen locations.

RESULTS

In total, 81 prey items were identified in the scats (Table 1). Wild ungulates dominated the diet (65.4%), with red, *Cervus elaphus*, and roe deer, *Capreolus capreolus*, accounting for 32.1 and 21%, respectively. Chamois, *Rupicapra rupicapra*, ibex, *Capra ibex*, mouflon, *Ovis gmelini*, and wild boar, *Sus scrofa*, were of secondary importance to wolves. On the other hand, domestic ungulates represented 27.1% of the items whereas other mammals such as rodents were occasionally eaten (7.4%).

Three wild species were identified as wolf kills. Red deer was the most frequent prey (57.1%; 36/63), followed by roe deer (27%; 17/63) and chamois (15.9%; 10/63). Red deer fawns were more often preyed upon (72%; 26/36) than adults (28%; 10/36). In contrast, roe deer and chamois carcasses were essentially adults, i.e. 94.1% (16/17) and 100% (10/10) respectively.

In the Surselva wolf core area (ca. 200 km^2), ungulate population estimates showed that red deer was the most abundant species (ca. 700 individuals; 50% of the ungulate community), followed by roe deer (ca. 500; 35.7%) and chamois (ca. 200; 14.3%; G. Sutter, pers. com.). Regarding prey selectivity, roe deer was preferentially eaten by the wolf (D = 0.38), and red deer taken according to its availability (D = 0.14). On the other hand, chamois was less frequent than expected in scats (D = - 0.49).

The altitude of the kill locations was lower and slopes were flatter than those of random locations, (Wilcoxon signed rank test, Z = 4.0398 and Z = 4.1001 respectively, p = 0.0001; Table 2). Kills were usually made in open areas, within 10 ±94 m from the nearest wood edge (Wilcoxon signed rank test, Z = 2.2652, p = 0.0235). Moreover, compared to random locations, wolf predation occurred closer to the nearest house and road (Wilcoxon signed rank test, Z = 2.2384 and Z = 2.2715, p = 0.0252 and p = 0.0231 respectively). In contrast, the distance to the nearest water way was apparently not a parameter influencing predation, but more kill sites (28 %; 15/40) than random ones (13.4 %; 16/119) were recorded in gullies and ravines (Fisher-exact test, p = 0.0369).

TABLE 2. Influence of various habitat parameters on kill location (Wilcoxon signed rank test). NS: non-significant

Parameter	Kill	Random	p
Altitude (m asl.)	1268 ±281	1472 ±283	< 0.01
Slope (°)	18.3 ±14	30.7 ±18	< 0.01
Distance (m) to the nearest wood edge	10 ±94	-41 ±161	< 0.05
Distance (m) to the nearest water way	178 ±207	202 ±191	NS
Distance (m) to the nearest road	88 ±68	166 ±169	< 0.05
Distance (m) to the nearest house	158 ±116	238 ±194	< 0.05

DISCUSSION

As in most European countries, wolves mainly feed on wild ungulates, essentially cervids, in the Swiss Alps. Red deer are not only the main item recorded in wolf scats, but also amongst wolf kills found in the wild. However, despite a relatively high frequency of occurrence in the diet, and with regards to game abundance notably in Surselva, red deer are taken according to their availability. In contrast, although less represented in the diet, roe deer are preferentially preyed upon by wolves as observed in Germany (Ansorge *et al.*, 2006). In Poland for instance, both ungulate species had the same vulnerability rate (Smietana & Klimek, 1993), whereas red deer were preferred by wolves in northern Italy (Gazzola *et al.*, 2005). During the study period, only lone wolves were present in Switzerland (Weber, 2008). No packs were constituted. Under these circumstances, it might be much easier for these solitary individuals to catch middle-sized prey such as roe deer. A similar hunting pattern was also recorded in the Cantabric Mountains (Spain) when wolves were re-colonizing this region (Vignon, 1997). In areas where packs occur, wolves prey much more upon larger animals (Jedrzejewski *et al.*, 2002), a feature that can be expected in the middle-term in the Swiss Alps, once wolves will start to form packs. The negative selection exhibited by wolves to chamois is likely related to a different mountainous habitat selection by chamois, i.e. in higher up and rugged areas, which potentially make any

capture attempt difficult and perilous (Poulle *et al.*, 1998). The occurrence of other wild prey in the diet is rather limited but through its diversity confirms the opportunistic feeding behaviour of the wolf. In this regard, scavenging of wild ungulates dying in winter for instance should not be discarded.

In some south-European regions, where pristine habitats were highly modified by man, wolves prey mainly on livestock (Meriggi *et al.*, 1991; Papageorgiou *et al.*, 1994; Meriggi & Lovari, 1996 amongst others) whereas in northern countries, domestic animals represent only a small dietary fraction (Andersone & Ozolins, 2004; Nowak *et al.*, 2005). Despite the richness of the Swiss Alps in wild ungulates, livestock are a significant part of wolf diet, particularly during summer. The same observations were made in the neighbouring alpine countries (Poulle *et al.*, 1997; Gazzola *et al.*, 2005). Sheep and goats are indeed ideal prey for wolves in terms of their high numbers on alpine pastures, their feeble fleeing capacity and often the lack of efficient protective measures, such as shepherds, livestock guarding dogs or electric fences.

In addition to possible idiosyncratic behaviours of wolves, several habitat parameters, of which altitude and slope are the most significant, influence the kill locations. Predation occurs at lower altitude and on gentler slopes than expected. It is no real surprise as most game carcasses were recovered during winter. In this season, wild ungulates are present where snow cover is less thick and food readily available, i.e. in the valley bottoms. This explains also the strong trend of wolves to kill their prey close to human settlements and roads. The latter is usually considered a disturbing factor for wolves (Jedrzejewski *et al.*, 2004; Potvin *et al.*, 2005). However in Switzerland, the road network is particularly dense notably in forested areas and it is not rare to observe wildlife using these ways to ease their movements in a rough habitat like the Alps (Weber, personal observations). The studies carried out in the Bieszczady Mountains (Poland) demonstrate that 74% of wild prey killed by wolves were attacked in ravines and gullies (Gula, 2004). Although we do not reach such a proportion, wolves use significantly more than expected these habitat features in hunting bouts. Gullies allow a predator to approach discreetly its prey before launching a sudden attack (Okarma, 1984).

Our study gives a preliminary figure of wolf feeding habits in Switzerland and confirms the results obtained in the neighbouring French and Italian alpine areas. The similarity of the data may be of some importance when defining and managing the alpine wolf population. At this stage, wolf conservation and management in the Alps depends on each individual country. In the future, we might expect a management carried out at a larger scale, i.e. on the entire alpine range, but further research and political will are clearly needed before reaching this objective.

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